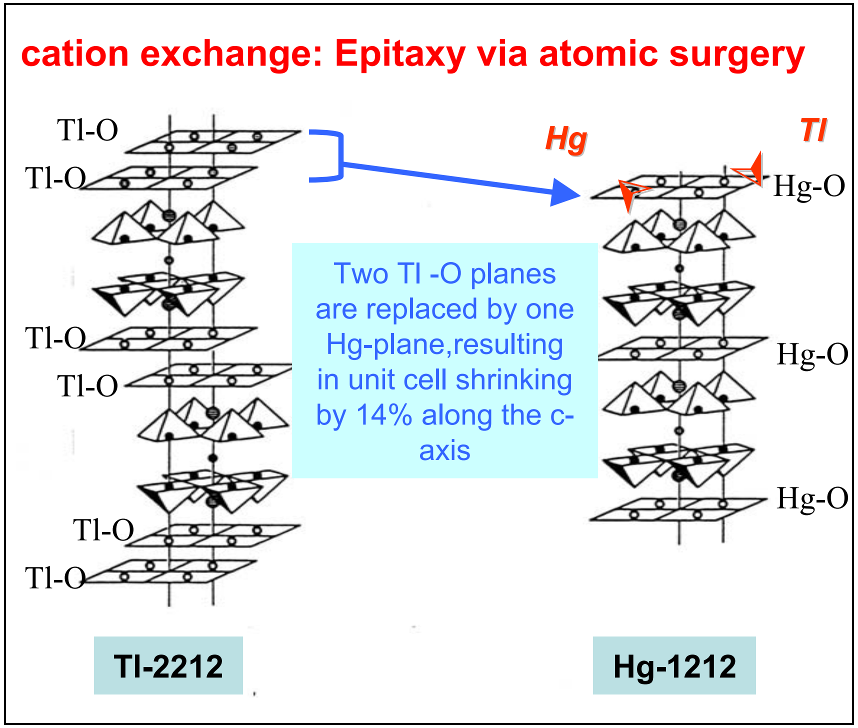
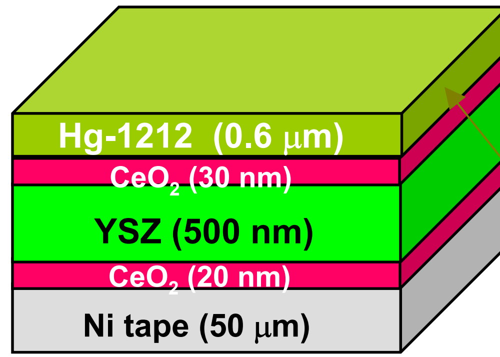
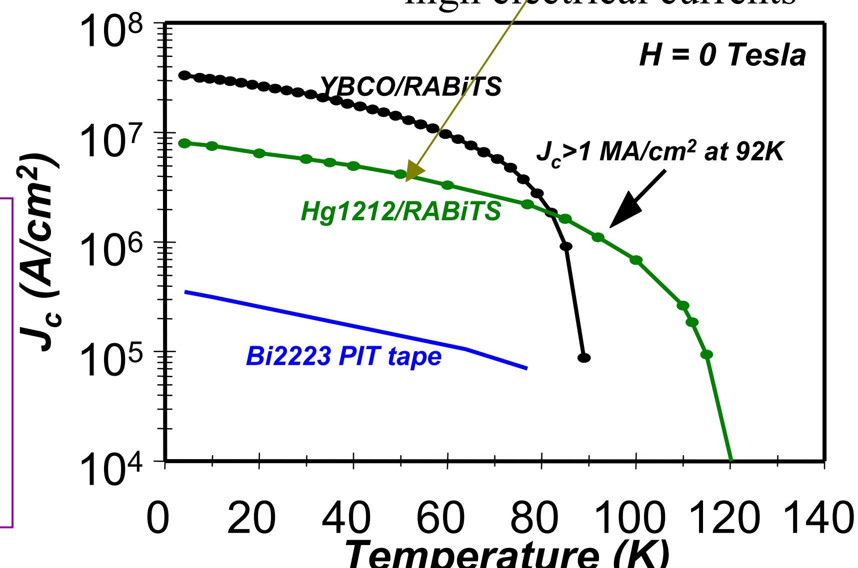
Development of the highest-T_c superconducting coated conductors for power applications

Judy Wu, University of Kansas; DMR-0206792





Superconductor (Hg-1212) coating on buffered metal tapes can carry high electrical currents



A new scheme--cation exchange (US patent awarded) --has been developed for epitaxy-equivalent synthesis of volatile compounds, such as Hg-1212. Hg-1212 on CeO_2/YSZ/CeO_2 buffered Ni tapes have been made with critical current density > 1MA/cm^2 at 92K, the highest so far achieved at 92K.

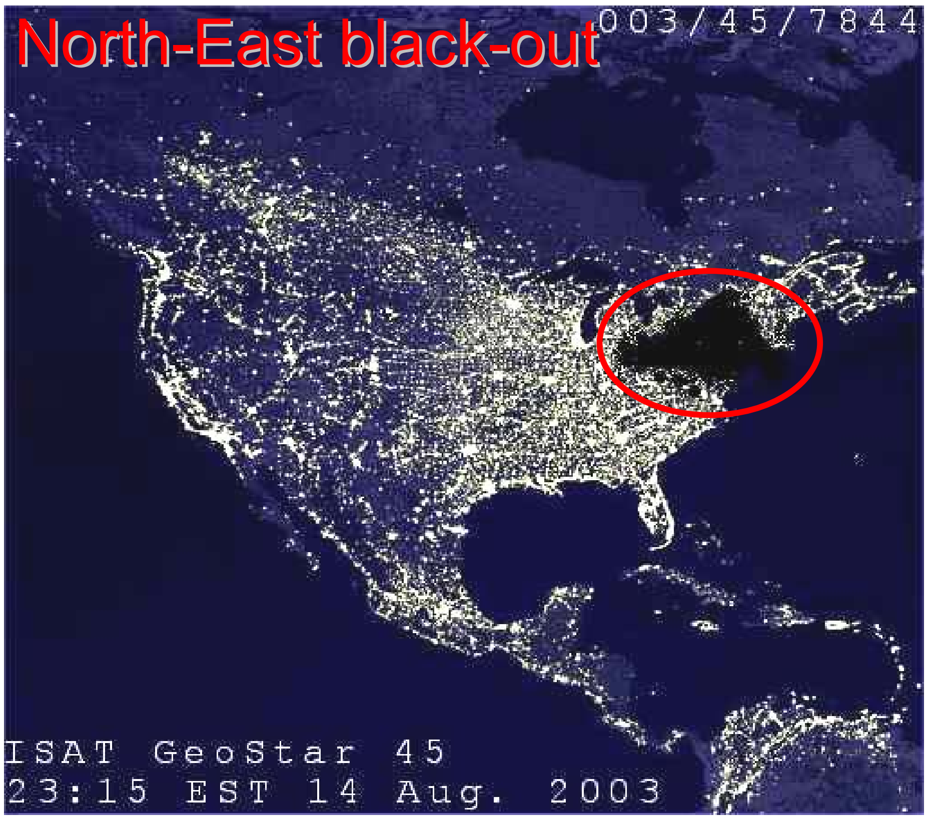
Cation exchange employs a precursor matrix that has a similar crystalline structure and chemical composition to that of the desired material. When this matrix is provided with perturbation energy (e.g., photo- or thermal excitation), cations move about their equilibrium lattice positions. With increasing excitation, weaker bonded cations are removed from the matrix, and replaced by desired cations provided in the synthesis chamber, yielding the desired material without decomposing the precursor crystalline lattice structure, or creating multiphase material. The whole process is like an “atomic surgery” to a precursor matrix, replacing certain cations with others desired. This cation exchange process enables epitaxy-equivalent synthesis of highly volatile materials (such as Hg-1212) that can not be obtained, or very difficult to obtain, using normal epitaxial conditions. The perturbation/excitation of the precursor cations may be highly selective by using optical excitation, greatly assisting the search for new materials with pre-designed structure and composition.

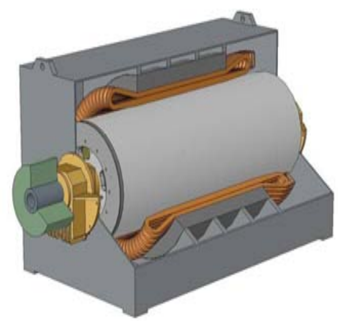
In the cation exchange epitaxy-equivalent synthesis of Hg-1212, two precursor matrices can be used, Tl-1212 and Tl-2212 to obtain the desired material. The former has the same crystalline structure as Hg-1212 while the latter with an additional Tl-O plane in each unit cell (as shown above). When Tl-1212 is employed as the precursor, each Tl cation in the unit cell is replaced with a Hg cation leaving the lattice structure essentially unchanged. In the case of Tl-2212, two Tl cations are replaced by one Hg cation, yielding a different structure having a reduction of the unit cell along the c-axis by ~ 14%. In general, structure/property/performance variations and evaluations are an important aspect of continued research activities.

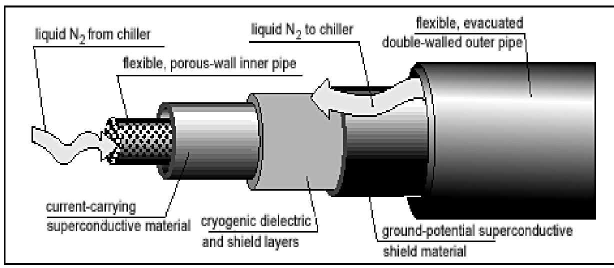
High Temperature Superconductivity (HTS) Benefits
(Judy Wu, University of Kansas; DMR-0206792)

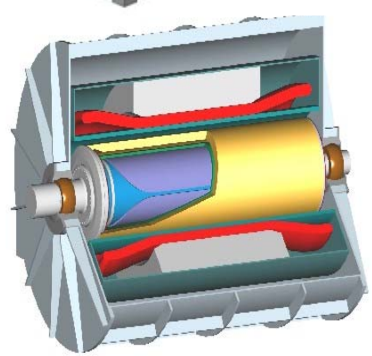
- ***power application of high-temperature superconducting wires in electric utilities***

HTS electric utility industry
Generators; transmission lines; transformers; power stability; energy storage (SMES)
[Energy savings of ~$13B by 2020]









The big-picture motivation for this work is shown here. HTS could have a tremendous impact on the future of several technologies: communications, medical diagnostics, and the utility and transportation industries, with ramifications of billions of dollars annual revenue and like values in energy savings. What remains is to fully develop the materials to realize their potential capabilities. Devices range from electronic sensors and active components to high-current wires.